SECTION 23 74 13
PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Roof top air handling units including integral components specified herein.

B. Definitions: Roof Top Air Handling Unit (Roof Top Units, RTU): A factory fabricated assembly consisting of fans, coils, desiccant wheel, ultra violet germicidal irradiation system, filters, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled on the drawings.

1.2 RELATED WORK

A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic restraints for equipment.

B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.

C. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Sound and vibration requirements.

D. Section 23 07 11, HVAC and BOILER PLANT INSULATION: Piping and duct insulation.

E. Section 23 21 13, HYDRONIC PIPING: Piping and valves.

F. Section 23 82 16, AIR COILS: Heating and cooling coils and pressure requirements.

G. Section 23 34 00, HVAC FANS: Return and exhaust fans.

H. Section 23 31 00, HVAC DUCTS and CASINGS: Requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining.

I. Section 23 40 00, HVAC AIR CLEANING DEVICES: Air filters and filters' efficiency.

J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: HVAC controls.

K. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC: Testing, adjusting and balancing of air and water flows.

L. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT: Types of motors.

M. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

N. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

O. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

P. Section 26 24 16, PANELBOARDS.

Q. Section 26 29 11, MOTOR CONTROLLERS: Types of motor starters.
R. Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS.
S. Section 26 51 00, INTERIOR LIGHTING.
T. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
U. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 QUALITY ASSURANCE

A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.
C. Performance Criteria:
   1. The fan BHP shall include all system effects for all fans and v-belt drive losses for housed centrifugal fans.
   2. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
   3. Select the fan operating point as follows:
      a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point.
      b. Air Foil, Backward Inclined, or Tubular Fans Including Plenum Fans: At or near the peak static efficiency but at an appropriate distance from the stall line.
   4. Operating Limits: AMCA 99 and Manufacturer’s Recommendations.
D. Units shall be factory-fabricated, assembled, and tested for air leakage and panel deflection by a manufacturer, in business of manufacturing similar air-handling units for at least five (5) years.
E. UL Compliance: Comply with UL Standard 1995 as applicable to usage of UVC Emitters in HVAC Equipment.
F. ISO Certification: UVGI Fixtures must be manufactured in a ISO 9001:2000 registered facility.

1.4 SUBMITTALS:

A. The contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES, furnish a complete submission for all roof top units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.
B. Manufacturer's Literature and Data:
   1. Submittals for RTUs shall include fans, drives, motors, coils, humidifiers, sound attenuators, mixing box with outside/return air dampers, filter housings, blender sections, desiccant wheel section,

and all other related accessories. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, diffusion plates, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, vibration isolators, drain pan, pressure drops through each component (filter, coil etc) and rigging points.

2. Submittal drawings of section or component only, will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves or certified computer selection data; data sheets; fabrication and insulation details; **if the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.** This data shall be submitted in hard copies and in electronic version compatible to AutoCAD version used by the VA at the time of submission.
3. Submit sound power levels in each octave band for fan and at entrance and discharge of RTUs at scheduled conditions. Include sound attenuator capacities and itemized internal component attenuation. Internal lining of supply air ductwork with sound absorbing material is not permitted. In absence of sound power ratings refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
4. Provide fan curves showing Liters/Second (cubic feet per minute), static pressure, efficiency, and horsepower for design point of operation and at maximum design Liters/Second (cubic feet per minute) and 110 percent of design static pressure.
5. Submit total fan static pressure, external static pressure, for RTU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule on drawings.

C. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.

D. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.

E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician

and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

F. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.

1. Units shall be shipped in one (1) piece where possible and in shrink wrapping to protect the unit from dirt, moisture and/or road salt.
2. **If not shipped in one (1) piece, provide manufacturer approved shipping splits where required for installation or to meet shipping and/or job site rigging requirements in modular sections. Indicate clearly that the shipping splits shown in the submittals have been verified to accommodate the construction constraints for rigging as required to complete installation and removal of any section for replacement through available access without adversely affecting other sections.**
3. If shipping splits are provided, each component shall be individually shrink wrapped to protect the unit and all necessary hardware (e.g. bolts, gaskets etc.) **shall be included to assemble unit on site** (see section 2.1.A4).
4. Lifting lugs shall be provided to facilitate rigging on shipping splits and joining of segments. If the unit cannot be shipped in one piece, **the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.**

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):

260-01.....Sound Rating of Ducted Air Moving and Conditioning Equipment

410-01.....Standard for Forced-Circulation Air-Heating and Air-Cooling Coils

430-09.....Standard for Central Station Air Handling Units

AHRI-DCAACP.....Directory of Certified Applied Air Conditioning Products

C. Air Moving and Conditioning Association (AMCA):

210-07.....Laboratory Methods of Testing Fans for Rating

D. Anti-Friction Bearing Manufacturer's Association, Inc. (AFBMA):

9-90 (R2008).....Load Ratings and Fatigue life for Ball Bearings

E. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
51-2007.....Laboratory Methods of Testing Fans for Rating

F. American Society for Testing and Materials (ASTM):
A653/653M-02.....Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
B117-07a.....Salt Spray (Fog) Testing
C1071-05e1.....Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
D1654-08.....Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
D1735-08.....Water Resistance of Coatings Using Water Fog Apparatus
D3359-08.....Standard Test Methods for Measuring Adhesion by Tape Test
E84-10.....Standard Test Method for Surface Burning Characteristics of Building Materials

G. Anti-Friction Bearing Manufacturer's Association, Inc. (AFBMA):
9-90.....Load Ratings and Fatigue life for Ball Bearings

H. Military Specifications (Mil. Spec.):
DOD-P-21035A-2003.....Paint, High Zinc Dust Content, Galvanizing Repair

I. National Fire Protection Association (NFPA):
NFPA 90A.....Standard for Installation of Air Conditioning and Ventilating Systems, 2009

J. Energy Policy Act of 2005 (P.L.109-58)

PART 2 - PRODUCTS

2.1 ROOF TOP AIR HANDLING UNITS

A. General:

1. Roof top units (RTU) shall be fabricated from insulated, solid double-wall galvanized steel without any perforations in draw-through configuration. Casing is specified in paragraph 2.1.C. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.275 kg of zinc per square meter (0.90 oz. of zinc per square foot) (G90). Aluminum constructed units may be provided subject to VA approval and documentation that structural rigidity is equal or greater than the galvanized steel specified.

2. The contractor and the RTU manufacturer shall be responsible for insuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components. All structural, piping, wiring, and ductwork alterations of units, which are dimensionally different than those specified, shall be the responsibility of the contractor at no additional cost to the government.
3. RTUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown on the drawings. The unit shall **be assembled into the largest sections possible subject to shipping and rigging restrictions**. The correct fit of all components and casing sections shall be verified in the factory for all units prior to shipment. All units shall be fully assembled as much as physically possible considering the manufacturing space (unless they are knocked down), **tested and then split to accommodate shipment and job site rigging.** On units not shipped fully assembled, the manufacturer shall tag each section and include air flow direction to facilitate assembly at the job site. Lifting lugs or shipping skids shall be **provided for each section to allow for field rigging and final placement of unit.**
4. The RTU manufacturer shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a local representative at the job site to supervise the assembly and to assure the units are assembled to meet manufacturer's recommendations and requirements noted on the drawings. Provide documentation that this representative has provided this service on similar jobs to the Contracting Officer. If a local representative cannot be provided, the manufacturer shall provide a factory representative.
5. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.
6. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure panel shall not exceed 1/240 of the span based on a differential static pressure of 1991 Pa (8 inches water gage) or higher.

B. Base:

1. Provide a heavy duty galvanized steel base for supporting all major RTU components. Bases shall be constructed of wide-flange steel I-beams, channels, or minimum 125 mm (5 inch) high 3.5 mm (10 Gauge) steel base rails. Welded or bolted cross members shall be provided as required for lateral stability. The maximum deflection shall not exceed 1/300.
2. RTUs shall be completely self supporting for installation on a full perimeter roof curb as specified below.
3. The RTU bases not constructed of galvanized material shall be constructed of aluminum or 304 stainless steel.
4. **Each module shall be provided with (4) lifting lugs for rigging purposes**.
5. The perimeter frame shall be thermally isolated from the casing. The thermal barrier shall have an R value equal or better then 0.71 m^2.K/W (0.4 ft^2.^oF.hr/Btu) minimum per inch.

C. Prefabricated Roof Curbs:

1. Construction: Galvanized steel, full perimeter type with continuous welded corner seams, two inch wall thickness, treated wood nailer, 38 mm (1-1/2 inch) thick, 48 kg per cubic meter (3 pound) density rigid mineral fiberboard insulation with metal liner, built-in cant strip, (except for gypsum or tectum decks). For surface insulated roof deck provide raised cant strip to start at the upper surface of the insulation. Curbs shall be built for pitched roof or ridge mounting as required to keep top of curb level.
2. Curb Height: Minimum 450mm (18 inches) above roof deck/300 mm (12 inches) above finished roof surface, or as required to obtain proper operation heights for cooling coil condensate drain trap and steam coil condensate return trap.

D. Casing (including wall, floor and roof):

1. General: RTU casing shall be entirely double wall insulated panels, integral of or attached to a structural frame. Construction shall be such that removal of any panel shall not affect the structural integrity of the unit. Casing finished shall meet salt-spray test as specified in paragraph 2.1.C.10. All casing and panel sections shall be tightly butted and gasketed. No gaps of double wall construction will be allowed where panels bolt to air handling unit structural member. Structural members, not covered by the double wall panels, shall have equivalent insulated double wall construction.
2. Double wall galvanized steel panels, minimum 102 mm (4 inches) thick, constructed of minimum 1.61 mm (16 gauge) outer skin and 1.0 mm (20

gauge) solid inner skin to limit wall, roof and floor deflection to not exceed an L/240 ratio when the unit casing is pressurized to (±1245 Pa (±5 in. w.g.). Interior skin for any cooling coils, steam or water injection humidifiers, or fully wetted sections shall be constructed from 1.0 mm (20 gauge) 304 stainless steel. Deflection shall be measured at the midpoint of the panel height. Total housing leakage shall not exceed 0.5% of rated cfm when the unit casing is pressurized to ±15 in. w.g. (±3735 Pa). The outer (skin) and inner panels shall be solid. The interior skin of the unit, which includes interior casing walls and roof, and all component supporting members including, but not limited to, filter racks, coil support racks, integral fan bases, etc. shall be provided with an antimicrobial electrostatic powder coat paint. The antimicrobial painting finish may also be applied in a baked on enamel painting process. Interior components and casings constructed from 304 stainless steel and any flooring surfaces shall not require the antimicrobial paint. Components and casing surfaces formed from antimicrobial silver ion steel shall not be acceptable.

3. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters. Blank-off material for all coil sections shall be 304 stainless steel.
4. Insulation: Insulation shall be fully injected CFC free polyurethane foam encased in double-wall casing between exterior and interior panels such that no insulation can erode to the air stream. Insulation shall be 102 mm (4 inch) thick, and 48 kg/m^3 (3.0 lb/ft^3) density with a total thermal resistance (R-value) of approximately 4.6 m.K/W (26.0 hr-ft^2 ^{O}F/BTU). Units with less than 102 mm (4 inch) of insulation in any part of the walls, floor, roof or drain pan shall not be acceptable. The panel assembly system shall have an overall thermal resistance equal to 13.2, as tested by an independent lab using the following procedure: ASTM C1363-05 Standard Test Method for Thermal Performance of Building Materials and Envelop Assemblies by means of a hot box apparatus. The insulation shall comply with NFPA 90-A for the flame and smoke generation requirements. Also, refer to specification Section 23 07 11, HVAC and BOILER PLANT INSULATION.

Table 2.1.C.4

Outer Panel	2.6 mm (16 Gage) Minimum
Inner Panel	1.0 mm (20 Gage) Minimum

Insulation Thickness Density	Foam 102 mm (4 inch) Minimum 48 kg/m^3 (3.0 lb/ft^3) Minimum
Total R Value	4.6 m^2.K/W (26.0 ft^2.^oF.hr/Btu) Minimum

5. The thickness of insulation, mode of application, and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU. Foam insulation shall be fully injected so that there are no voids on uninsulated spaces between the exterior and interior panels. Foam board insulation shall not be acceptable.
6. Casing panels shall be secured to the support structure with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are not acceptable.
7. Access Doors: Provide in each access section and where shown on drawings. Show single-sided and double-sided access doors with door swings on the floor plans. Doors shall be a minimum of 102 mm (4 inches) thick with same double wall construction as the unit casing. Doors shall be a minimum of 600 mm (24 inches) wide, unless shown of different size on drawings, and shall be the full casing height up to a maximum of 1850 mm (6 feet). Doors shall be gasketed, hinged, and latched to provide an airtight seal. The access doors for fan sections, mixing box, humidifier and coil sections shall include a minimum 150 mm x 150 mm (6 inch x 6 inch) double thickness, with air space between glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.
   a. Hinges: Manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 45 kg (100 pound) weight hung on latch side of door.
   b. Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 0.785 radian (45 degrees) further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 1991 Pa (8 inches water gage).
   c. Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket.

Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.

d. Door Test Ports: Provide a test port with cap for each access door for insertion devices for static pressure and velocity measurements.

8. Provide a service vestibule the same construction of the casing specified above and size as indicated on the drawings. Vestibule shall be integral to the unit casing and base and shall not be a bolt on structure. The service vestibule shall be provided with lights, light switches, (3) GFI receptacles, and all air handling unit fan motor starters, variable frequency drives, power panels, and electrical disconnects, all factory mounted and wired. 120 volt loads shall be factory wired to clearly labeled junction boxes located within the service vestibule. All breaker sizing and wiring shall be compliant with NEC 2011. All panels, disconnects, etc. shall be rated for 10,000 short circuit amps. Refer to division 26 specification sections listed above in 1.2 for additional requirements/information.
9. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring. Coordinate with electrical and temperature control subcontractors for number and location of penetrations. Coordinate lights, switches, and duplex receptacles and disconnect switch locations and mounting. All penetrations and equipment mounting may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.
10. Roof of the unit shall be sloped to have a minimum pitch of 1/4 inch per foot. The roof shall overhang the side panels by a minimum of three inches to prevent precipitation drainage from streaming down the unit side panels.
11. Casing finished shall meet ASTM B117, 500-hour salt spray test, using 20 percent sodium chloride solution. Immediately after completion of the test, the coating shall show no sign of blistering, wrinkling, or cracking, no loss of adhesion, and the specimen shall show no sign of rust creepage beyond 1/8-inch on either side of scratch mark.
12. Individual panels, access doors, flooring system, and roofing system shall be provided with a no-thur-metal thermal resistance system so that there are no points of continuous metal to metal contact which would allow heat transfer between the unit exterior and interior

surfaces. No thru metal joining systems that utilize gaskets or gasketing systems shall not be acceptable.

E. Unit floor shall be level without offset space or gap and designed to support a minimum of 488 kg/square meter (100 pounds per square foot) distributed load without permanent deformation or crushing of internal insulation. The top flooring surface of the unit shall be 3.175 mm (0.125 inch) thick aluminum treadplate, fully recessed with a minimum depth of 25.4 mm (1 inch), that is fully welded to provide a completely self-draining flooring system. Provide floor drains or catch basins in each unit section. The floor insulation shall be 102 mm (4 inch) thick, and 48 kg/m^3 (3.0 lb/ft^3) density with a total thermal resistance (R-value) of approximately 4.6 m.K/W (26.0 hr-ft^2 ^oF/BTU). The floor underliner shall be 0.85 mm (22 gauge) galvanized steel. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation. Unit floors in casing sections, which may contain water or condensate, shall be watertight with drain pan. All floor opening shall be equipped with a 38.1 mm (1-1/2 inch) raised floor collar to prevent water migration into the floor opening. Air inlet and discharge openings shall be protected with G-90 galvanized steel flat bar grating.

F. Condensate Drain Pan: Drain pan shall be designed to extend entire length of cooling coils including headers and return bends. Depth of drain pan shall be at least 43 mm (1.7 inches) and shall handle all condensate without overflowing. Drain pan shall be double wall construction, Type 304 stainless steel and have a minimum of 50 mm (2 inch) insulation, and shall be sloped to drain. Drain pan shall be continuous metal or welded watertight. No mastic sealing of joints exposed to water will be permitted. Drain pan shall be placed on top of casing floor or integrated into casing floor assembly. Drain pan shall be pitched in all directions to drain line.

1. An intermediate condensate drip pan shall be provided on stacked cooling coils and shall be the same length and depth of the primary drainpan and shall be constructed of type 304 stainless steel with 304 stainless steel downspouts factory piped to main condensate pan. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.
2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.

3. Installation, including frame, shall be designed and sealed to prevent blow-by.

G. Plenum Fans – Single and/or Multiple Fans in an Array

1. General: Fans shall be Class II (minimum) construction with single inlet, aluminum wheel and stamped air-foil aluminum bladed. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4. Fans shall be dynamically balanced and internally isolated to minimize the vibrations. Provide a steel inlet cone for each wheel to match with the fan inlet. Locate fan in the air stream to assure proper flow. The fan performance shall be rated in accordance with AMCA 210 or ASHRAE 51.
2. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC. The fan wheel shall meet or exceed guidelines in AMCA 801-92 for dynamic balancing requirements. The complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).
3. The plenum fans shall be driven by variable speed drives with at least one back-up drive as shown in the design documents. Use of a drive with bypass is not permitted. Provide (1) one variable speed drive for every (2) two fan motors. Provide short circuit protection of motor circuits through means of using fuses with fuse blocks or circuit breakers.
4. Multiple fans shall be installed in a pre-engineered structural frame to facilitate fan stacking. All fans shall modulate in unison, above or below the synchronous speed within the limits specified by the manufacturer, by a common control sequence. Staging of the fans is not permitted. Redundancy requirement shall be met by operating all fans in an array and without the provision of an idle standby fan.
5. Fan Accessories
   a. Fan Isolation: Provide an actuator-controlled damper to isolate the fan not in operation due to failure.

b. Fan Airflow Measurement: Provide an airflow measuring device integral to each fan to measure air volume within +/- 5 percent accuracy. The probing device shall not be placed in the airflow path to stay clear of turbulence and avoid loss of performance. A surface mounted indicator, located on the unit exterior, shall provide a digital CFM readout, and/or a (4-20 ma) (0-10 volt) output control signal for use in the FMS.

c. Provide motor lifting rails and trolley system to facilitate the lifting and handling of the motor to the exterior of the AHU cabinet. The rails shall include an extendible mechanism to ensure that the motors can be handled to the service vestibule of the AHU cabinet. Rails shall be structural high grade carbon steel and shall be finished with a powder coated safety yellow.

6. Fan Motor, Drive and Mounting Assembly: Fan Motors shall be premium energy efficient type, as mandated by the Energy Policy Act of 2005, with efficiencies as shown in the Specifications Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT, on drawings and suitable for use in variable frequency drive applications. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC, for additional motor and drive specifications. Refer to Specification Section 26 29 11, MOTOR STARTERS.

H. Economizer Section: Economizer Section shall consist of casing and outdoor air, return air and exhaust air dampers in opposed blade arrangement with damper linkage for automatic operation. Coordinate damper operator with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Dampers shall be of ultra-low leak design with double wall, thermally broken, extruded aluminum airfoil blades, with metal compressible bronze jamb seals and extruded vinyl edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings or bronze bushings. Leakage rate shall not exceed 1.6 cubic meters/min/square meter (5 cfm per square foot) at 250 Pa (1 inch water gage) and 2.8 cubic meters/min/square meter (9 cfm per square foot) at 995 Pa (4 inches water gage) Electronic damper operators shall be furnished and mounted in an accessible and easily serviceable location by the air handling unit manufacturer at the factory. Damper operators shall be of same manufacturer as controls furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. The entire outside air damper section shall be provided with an integral system of outside air flow measurement. System shall be capable of a 6 to 1 turn down of listed design cfm (not minimal unit size cfm), providing a stable reading with an accuracy of +/-5 percent of actual air flow throughout the entire

range. Provide minimum/maximum damper sections if required, and coordinate quantity and arrangement of actuators with the building automatic temperature control system. System shall be provided with low voltage power supply, electronics to provide a 4-20 ma or 2-10 VDC signal for reading by the building automatic temperature control system and receiving a control signal (4-20 ma or 2-10 VDC) from the building automatic temperature control system for damper positioning. Ambient operating range of -20 degrees F to 150 degrees F at specified accuracy. Coordinate all input/output point requirements, hardware, software and wiring requirements with the building automatic temperature control system, as well as required straight lengths of inlet duct.

I. Blenders: Construction of the blender section shall be of welded aluminum 2 mm (0.081 inch) thick framing and turbulators. The mixer shall have no moving parts and shall contain a primary set of directional changing vanes, a secondary set of turbulator vanes, and a cone design for mixing of air streams. Certify blender performance to achieve no more than a 5°F variation across the cross section of the AHU measured 12 inches downstream of the blender over a face velocity range of 1-4 m/s (200-800 FPM).

J. Filter Section: Refer to Section 23 40 00, HVAC AIR CLEANING DEVICES, for filter requirements.
   1. Filters including one complete set for temporary use at site shall be provided independent of the RTU. The RTU manufacturer shall install filter housings and racks in filter section compatible with filters furnished. The RTU manufacturer shall be responsible for furnishing temporary filters (pre-filters and after-filters, as shown on drawings) required for RTU testing.
   2. Factory-fabricated filter section shall be of the same construction and finish as the RTU casing including filter racks and hinged double wall access doors.

K. Coils: Coils shall be mounted on 304 stainless steel supports to assure proper anchoring of coil and future maintenance. Coils shall be face or side removable for future replacement thru the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to insure no condensate carry over. Provide factory installed extended supply, return, drain, and vent piping connections. Refer to Drawings and Section 23 82 16, AIR COILS, for additional coil requirements.
   1. Water Coils
   2. Integral Face and Bypass Steam Coils: Provide integral vertical face and bypass dampers. Coil shall be capable of maintaining a constant

discharge air temperature within +/-15° C (5° F) regardless of variations in entering air temperature. Finned heating elements shall be fabricated of seamless 15.9 mm (5/8 inch) O.D. hairpin type copper tubes with 0.89 mm (0.035 inch) wall thickness. Fins shall be rectangular embossed aluminum with a thickness of 0.254 mm (0.010 inch). Headers shall be constructed of Schedule 40 steel pipe with a minimum wall thickness of 5.5 mm (0.216 inch). Each tube shall be free to expand and contract individually. Channel-shaped tube retainers shall maintain distances between tubes and shall be free floating to allow for tube expansion. Intake dampers shall be constructed of heavy gauge G90 galvanized steel die-formed to an aerodynamic shape designed for minimum airflow resistance. Outlet dampers shall be constructed of heavy gauge G90 galvanized steel. Electric damper operators shall be furnished and mounted by the RTU manufacturer at the factory. Damper operators shall be of same manufacturer as controls furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

L. Humidifier:
   1. Steam separator type that discharges steam into the air stream through a steam jacketed distribution manifold or dispersion tube. Humidifiers shall be complete with Y-type steam supply strainer; modulating, normally closed steam control valve; normally closed condensate temperature switch; and manufacturer's standard steam trap.
   2. Steam separator: Stainless steel or cast iron.
   3. Distribution manifold: Stainless steel, composed of dispersion pipe and surrounding steam jacket, manifold shall span the width of duct or air handler, and shall be multiple manifold type under any of the following conditions:
      a. Duct section height exceeds 900 mm (36 inches).
      b. Duct air velocity exceeds 5.1 m/s (1000 feet per minute).
      b. If within 900 mm (3 feet) upstream of fan, damper or pre-filter.
      d. If within 3000 mm (10 feet) upstream of after-filter.
   4. Condensate Drain Water Tempering Device: temperature actuated valve, vacuum breaker, service union stainless steel mixing chamber, adjustable floor stand, all required sensors and additional accessories to ensure wastewater discharged into the building drainage system is not higher than 140 deg. F.

M. Sound Attenuators: Refer to Drawings, Specification Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT, and Section 23 31 00, HVAC DUCTS AND CASINGS, for additional unit mounted sound

attenuator requirements. RTU sound attenuators shall be factory installed as an integral part of RTU. Attenuators shall be made of continuous height baffles and constructed from 0.85 mm (22 gauge) galvanized steel. Media shall be shot-free glass fiber insulation with fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to ensure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber. The acoustic media shall be completely wrapped with Tedlar film. Silencer materials, including acoustic media, Tedlar film shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723

N. Air-to-Air Desiccant Wheel:

1. The air-to-air desiccant wheel shall include a desiccant wheel utilizing a fractional horsepower electric motor and a variable speed drive and reactivation air flow indicating devices steam, reactivation energy modulation system, electric/mechanical rotation fault circuitry and necessary manual and automatic dampers for proper functioning of the unit under all operating conditions. Desiccant wheels 1524 mm (60 inches) in diameter and smaller shall be a single piece for fast removal and simple handling. Belt-driven desiccant wheels shall be supported by four rollers at the base of the unit. The wheel rotational speed shall not exceed 15 rph while achieving the required moisture removal rate at the specified conditions. The drive motor shall be fractional horsepower and rated for continuous duty for a period of 20,000 hours under the load conditions imposed by the drive assembly. The drive assembly shall be equipped with a rotation detection circuit which shuts down the dehumidifier and signals the Building Automation Controls through an alarm if the wheel is not rotating.
2. Desiccant wheel shall rotary type, designed for continuous operation, and arranged to provide a counter flow of process and reactivation air streams with full-face pressure seals or low-friction contact seals on both sides to prevent cross leakage for external static pressure of up to 622 Pa (2.5 inches w.g.).
3. Desiccant rotor shall have synthesized silica gel, enhanced with titanium, bonded to a polymer matrix, with filled voids and encapsulating the ceramic. Driver shall be a motor with adjustable drive sheaves and belt-tensioning idler pulley or adjustable motor mount.

4. The rotary desiccant shall transfer water in the vapor phase. The design and geometry shall provide for laminar flow over the operating range for minimum pressure loss with maximum transfer surface and minimum power requirements. The desiccant shall be a permanent integral part of the structure. Nominal face velocity shall not exceed 1000 fpm.
5. Provide documentation to establish that the desiccant retains more than 90% of its original capacity after ten years of continuous operation in clean air, with inlet air conditions up to and including 100% relative humidity and the wheel as impregnated with silica gel is capable of withstanding five complete water immersion cleaning cycles while retaining more than 95% of its original adsorption capacity.

O. Ultra Violet Germicidal Irradiation (UVGI) System
1. A UVC disinfection system shall be furnished for air handling unit installation, located in the AHU's. The system shall be based on AHU specific information and shall be designed to maintain its efficiency over one year.
2. Each fixture and emitter shall be factory assembled, and independently tested to verify output used in the calculations of irradiation as specified below. When tested in accordance with the general provisions of IES Lighting Handbook, 1981 applications volume, total output per inch arc length shall not be less than 10 $\mu W/CM^2$ at 1 meter, in moving airstream of 45°F. and 400 FPM.
3. Design Requirements:
   a. Irradiation - Emitters and fixtures are to be installed in sufficient quantity and in such an arrangement so as to provide an equal distribution of UVC energy on the coil and in the drain pan. To maintain energy efficiency, the UVC energy produced shall exhibit the lowest possible reflected and shadowed losses.
   b. Intensity - Initial incident intensity shall exceed 500 uW/cm2. End of life intensity (8000 hrs) shall exceed 250 uW/cm2. UV installation shall have a total minimum efficiency of 99% for 12 months. Shall be measured by a Solid State Photodiode UV Sensor. Calibration wavelength is 254 nm. Accuracy is to be _+ 10% and be NIST traceable. Operating range shall be 32^0 F- 150^0 F. Read by a Display module with a 3.5 digit LCD screen/panel. Irradiance range shall be 0-1999 (x10) $\mu W/cm^2$ with a resolution of 10 µW/cm.

c. Installation - Emitters and fixtures shall be installed downstream of the cooling coil at right angles to the coil fins, such that UVC energy bathes all surfaces of the coil and drain pan.

4. Equipment:
   a. Units shall be high output, HVAC-type, germicidal UVC light sources, factory assembled and tested. Components shall include housing, reflector, where appropriate, high efficiency electronic power source, Emitter sockets and Emitter tube, all constructed to withstand HVAC environments.
   b. Compatible mounting structure shall be provided for the fixtures and Power Sources.
   c. Unit housings shall be made of 304 stainless steel, having electrical connectors on both ends to simplify gang wiring and wiring to power. They shall include mounting holes to assist in securing the fixtures.
   d. Reflectors (where applicable) shall be constructed of high spectral finished aluminum alloy with a minimum 85% reflectance of 254-nm UVC energy.
   e. High efficiency electronic power sources shall be 115 or 208/230 Vac/60/1 as indicated on the drawings. They shall be UL listed to comply with UL Standard 1995 and capable of igniting each Emitter at temperatures from 35 - 150° F in airflow velocities to 1000 fpm. They shall be equipped with RF and line noise suppression.
   f. Emitter tube shall be of the high output, hot cathode, T5 (15mm) diameter, and medium bi-pin type or single ended four pin connectors. Emitters shall be enclosed in teflon sleeve to protect emitter and for preventing glass shards from scattering if emitter is broken. They shall produce 95% of their energy at 254 nm and be capable of producing the specified output at airflow velocities to 1000 fpm at temperatures of 35 - 150° F. UVC Emitters shall produce no ozone or other secondary contamination.
   g. UV Radiometer or amp meter shall be supplied to monitor the UV radiation. The Radiometer shall monitor the radiation output in both uW/cm2 and in user defined preset percentages. The Radiometer shall have a display screen and display a visual indication of relative power of the UV lamp output. The radiometer shall provide lamp monitoring data as a 4-20mA output to the Building Control System.
   h. A UV control panel shall be provided for each bank of UV emitters. The control panel shall include a transformer, lockout relay,

door interlock switches, Indicator Lights ("On" and "Tripped"), and disconnect switch. Provide a disconnect switch downstream of the factory wired junction box to be located in the service vestibule.

i. Equipment control panels containing power control components shall be marked with the minimum SCCR rating.

j. Mounting frame for emitters shall be designed and supplied by UV manufacturer and shall be installed and wired by the air handling unit manufacturer.

1. System Performance:

a. The UVGI system shall be designed and engineered for the inactivation of airborne pathogens, specifically Streptococcus pneumoniae, Staphylococcus aureus, Serratia marcescens and Pseudomonas aeruginosa and shall have a total minimum efficiency of 99% for a minimum of twelve (12) months.

b. The system shall be effective on all micro organisms on exposed surfaces or passing with the air stream.

2. System Dose and Intensity:

a. The system shall demonstrate a minimum intensity of 250 $\mu W/cm^2$ at the irradiated CW coil/final filter compartment corner surface for the specific targeted microorganisms through the designated inactivation zone arrived at through known intensity, exposure time and UVC sensitivity of the microorganisms without emitter change-out over the twelve month operational period. This shall be accomplished by computing the UVC intensity pattern along an 'average intensity path', for a microorganism traveling through the air handling unit. The design software shall calculate the inactivation rate for the specific microorganism(s). Factors such as plenum configuration, air velocity and temperature and compartment surface material of the air handling unit shall be included in the calculation as well as the specific decay rate constant for each type of microorganism shall be applied to determine the efficacy required to maintain the calculated efficiencies.

The calculated dose shall be sufficient to ensure inactivation of the specified pathogenic organisms entering and passing through the air handling unit via the return air and outside air.

The design software shall calculate the optimized placement and emitter configuration for immediate response time effectiveness. Initial minimum intensity level and average dose shall be provided with submittals. Intensity calculations are based on formulas for

Radiant Heat Transfer theories and demonstrated per System Compliance Verification below.

b. Calculated intensity profile including average dose (mJ/cm²) and minimum intensity (mW/cm²) shall be provided with submittals.

3. System Compliance Verification - System array design minimum intensity shall be demonstrated by measuring at the top and bottom corners of the chilled water coil and/or surface in the same plane as the irradiated surface. Verification shall be conducted upon installation and activation of system with the AHU in operation. Verification shall be made using an International Light or similar calibrated radiometer/photometer accurate to + 3% radiometric and photometric for NIST transfer standards in the monochromatic irradiance at 254nm or similar. Recorded intensity measurements shall verify the calculated intensity implemented in the design software. This shall be used to verify compliance. A report in executive summary format shall be presented upon submission of Operation and Maintenance manuals.

4. Documentation - A minimum of two Operation & Maintenance Manuals shall be provided. The O&M Manual shall include:
   a. General component specification.
   b. System layout.
   c. Wiring Diagram.
   d. MSDS for emitters.
   e. Safety instructions.
   f. List of spare parts.
   g. Component specification sheets for control panel.

P. Discharge Section: Provide aerodynamically designed framed discharge openings or spun bellmouth fittings to minimize pressure loss. Provide a galvanized steel safety grate over all floor openings in the unit.

Q. Electrical and Lighting: Wiring and equipment specifications shall conform to Division 26, ELECTRICAL. Refer to all Division 26 sections, but particularly the sections listed in 1.2 above.

1. Vapor-proof lights using cast aluminum base style with glass globe and cast aluminum guard shall be installed in access sections for fans, mixing box, humidifier and any section over 300mm (12 inch) wide. A switch shall control the lights in each compartment with pilot light mounted outside the respective compartment access door. Wiring between switches and lights shall be factory installed. All wiring shall run in neatly installed electrical conduits and terminate in a junction box for field connection to the building

system. Provide single point 115 volt - one phase connection at junction box.

2. Install compatible 26 watt compact fluorescent bulb in each light fixture.
3. Provide a convenience duplex weatherproof receptacle next to the light switches serving fan sections.
4. Disconnect switch(s) and power wiring: Provide GFI receptacles, and all air handling unit fan motor starters, variable frequency drives, power panels, and electrical disconnects, all factory mounted and wired. 120 volt loads shall be factory wired to clearly labeled junction boxes located within the service vestibule. All breaker sizing and wiring shall be compliant with NEC 2011. All panels, disconnects, etc. shall be rated for 10,000 short circuit amps. Refer to division 26 specification sections listed above in 1.2 for additional requirements/information.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install roof top unit in conformance with ARI 435.

B. Assemble roof top unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Military Spec. DOD-P-21035A. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air-handling units clean prior to operation.

C. Install seismic restraints for roof top units. Refer to specification Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

D. Leakage and test requirements for roof top units shall be the same as specified for ductwork in Specification Section 23 31 00, HVAC DUCTS AND CASINGS except leakage shall not exceed Leakage Class (C_L) 12 listed in SMACNA HVAC Air Duct Leakage Test Manual when tested at 1.5 times the design static pressure. Repair casing air leaks that can be heard or felt during normal operation and to meet test requirements.

E. Perform field mechanical (vibration) balancing in accordance with Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

F. Seal and/or fill all openings between the casing and RTU components and utility connections to prevent air leakage or bypass.

G. UVGI:

1. The UVGI system shall be installed in the air handling unit as indicated on the drawings or otherwise required. Install such that

fixture and emitter shall be accessible for maintenance and emitter replacement and per manufacturer's instructions.

2. The UVGI system shall be installed per system supplier design, ensuring design criteria is met, within the specified air handling unit to treat the moving air at the designated velocity and temperature. Installation shall be per layout in mechanical drawings section or as otherwise required.
3. The UVGI system shall be designed for modularity and flexibility for ease of potential upgrades without changing footprint or performance of designated HVAC equipment or to accommodate system disassembly and relocation into different HVAC equipment without the need for demolition.

3.2 STARTUP SERVICES

A. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated and fan has been test run under observation.
B. After the air handling unit is installed and tested, provide startup and operating instructions to VA personnel.
C. An authorized factory representative shall start up, test and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Owner/Operator training, etc.
D. Provide UVGI system operation and safety training for all maintenance and service personnel who will need to come in contact with the UVGI system once installation is complete and functional. This training shall cover:
   1. System operation and functions.
   2. Safety protocols for viewing, entering and exiting the UVGI section of the system.
   3. Protocols for cleaning and changing emitters as per UVGI manufacturer's operation and maintenance manual.
   4. Protocols for handling of broken emitters as per UVGI manufacturer's MSDS information.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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